REMARKS

In view of the above amendments and following remarks, reconsideration and further examination are requested.

In response to the objection to the drawings, please note that replacement formal drawings have been provided for Figures 16A, 16B and 17A-17D, which labels these figures as --Prior Art--.

The specification and abstract have been reviewed and revised to make editorial changes thereto and generally improve the form thereof, and a substitute specification and abstract are provided. No new matter has been added by the substitute specification and abstract.

By the current Amendment, claims 1-14 have been canceled and claims 15-30 have been added.

The instant invention pertains to a circuit substrate to be used for packaging a semiconductor device, and a package including the circuit substrate and a semiconductor device. Circuit substrates used for packaging a semiconductor device, and packages including such a circuit substrate and a semiconductor device, are known in the art, but suffer from drawbacks as explained on pages 1-7 of the original specification. Applicants have addressed and resolved these drawbacks by developing a unique circuit substrate that is to be used for packaging a semiconductor device, and a package structure including this circuit substrate and a semiconductor device.

With reference to Figure 1A, for example, the inventive circuit substrate comprises a main body 1 having input/output terminal electrodes 2 on a surface thereof, conductive adhesive layers or portions 3 on the input/output terminal electrodes 2, and a resin film 4 on the main body and covering the input/output terminal electrodes 2 and the conductive adhesive portions 3.

With reference to Figures 2A and 2B, for example, in order to use this circuit substrate to package a semiconductor device 5, bump electrodes 7 of the semiconductor device 5 are forced through the resin film 4, through the conductive adhesive portions 3 and into contact with the input/output terminal electrodes 2.

Additionally, as shown in Figure 6B, for example, an elastomer layer 9 can be provided on a surface of the resin film that is to oppose the semiconductor device.

Independent claims 15, 19 and 23 are believed to be representative of the circuit substrate and a package including the circuit substrate and a semiconductor device, as described above.

Claims 1, 2 and 10 were rejected under 35 U.S.C. § 102(b) as being anticipated by Kunitomo et al. This rejection is respectfully traversed in part, and Kunitomo et al. is not applicable with regard to the newly added claims for the following reasons.

Independent claim 15 recites a circuit substrate that comprises

> a main body having input/output terminal electrodes on a surface thereof, with each of said input/output terminal electrodes having
> (i) a first surface that opposes said surface of said main body, and
> (ii) a second surface that faces in a direction opposite to that in which said first surface faces;
> conductive adhesive portions on said input/output terminal electrodes, with each of said conductive adhesive portions having
> (i) a first surface that opposes said second surface of a respective one of said input/output terminal electrodes, and
> (ii) a second surface that faces in a direction opposite to that in which said first surface faces; and
> a resin film on said surface of said main body and covering said input/output terminal electrodes along with said conductive adhesive portions such that said resin film covers said first and second surfaces of said input/output terminal electrodes and also covers said first and second surfaces of said conductive adhesive portions.

Such a circuit substrate is not taught or suggested by Kunitomo et al.

In this regard, Kunitomo et al. discloses a semiconductor device that comprises an insulating substrate 11, electrodes 12 on the insulating substrate, conductive adhesive 13 on the electrodes, and resin 14 between semiconductor chip 10 and the insulating substrate 11. However, contrary to what is required by claim 15, this resin 14 does not cover surfaces of the electrodes 12 that oppose the insulating substrate 11, nor surfaces of the electrodes 12 and the conductive adhesive 13 that oppose one another, nor surfaces of the conductive adhesive 13 that oppose the semiconductor chip 10.

Rather, the resin 14 is laterally offset from the surfaces, such that the resin does not cover these surfaces. Accordingly, claim 15 is not anticipated by Kunitomo et al.

Independent claim 19 recites a circuit substrate that comprises *inter alia*

> a main body...a resin film having on one surface thereof conductive adhesive portions...and having on an opposite surface thereof an elastomer layer.

The significance of the elastomer layer is that it can protect a functional portion of a semiconductor device, when mounted to the circuit substrate, from vibration or impact. A circuit substrate including a resin film having conductive adhesive portions on one side thereof and an elastomer layer on an opposite side thereof, is not taught or suggested by Kunitomo et al.

In this regard, while the conductive adhesive 13 of Kunitomo et al. can arguably be said to be on one side of the resin 14, there is nothing in Kunitomo et al. that can reasonably be said to correspond to the elastomer layer on an opposite side of resin 14, as required by claim 19. Accordingly, claim 19 is not anticipated by Kunitomo et al.

Independent claim 23 recites a package structure that comprises *inter alia*

> a circuit substrate having input/output terminal electrodes, and conductive adhesive on each of said input/output terminal electrodes;
>
> a semiconductor device having bump electrodes that are electrically and mechanically connected to said conductive adhesive and to said input/output terminal electrodes...**said bump electrodes being in contact with said input/output terminal electrodes** (emphasis added).

The significance of having the bump electrodes be in contact with the terminal electrodes is that reliability of the semiconductor device is improved. Such a package structure is not taught or suggested by Kunitomo et al.

In this regard, the bump electrodes 9 on the semiconductor chip 10 are not in contact with the electrodes 12. Rather, the bump electrodes 9 are spaced from the electrodes 12 by the conductive adhesive 13. Thus, claim 23 is not anticipated by Kunitomo et al.

Additionally, claim 18 is believed to be patentable in its own right, because the resin 14 of Kunitomo et al. does not cover the electrodes 12 and the conductive adhesive 13 on two of the three sides as recited in claim 18. In this regard, resin 14 only covers each electrode 12 and conductive adhesive 13 on a lateral side thereof

Also, claim 20 is believed to be patentable in its own right, because this claim recites that the resin film, with the conductive adhesive portions and elastomer layer thereon, is initially separate from the main body of the circuit substrate. In Kunitomo et al., resin 14 is injected into a space between semiconductor chip 10 and insulating substrate 11, such that resin film formed from this injected resin is never separate from the insulating substrate.

And, claim 24 is believed to be patentable in its own right, because Kunitomo et al. does not disclose or suggest an elastomer layer interposed between the resin and a functional part of the semiconductor device. As noted above, Kunitomo et al. fails to disclose or suggest any elastomer layer in combination with resin 14.

In view of the above amendments and remarks, it is respectfully submitted that the present application is in condition for allowance, with the allowed claims being 15-30, and an early Notice of Allowance is earnestly solicited.

If after reviewing this Amendment, the Examiner believes that any issues remain which must be resolved before the application can be passed to issue, the Examiner is invited to contact the Applicants' undersigned representative by telephone to resolve such issues.

Respectfully submitted,

Masahiro ONO et al.

By: Joseph M. Gorski

Joseph M. Gorski
Registration No. 46,500
Attorney for Applicants

JMG/edg
Washington, D.C. 20006-1021
Telephone (202) 721-8200
Facsimile (202) 721-8250
February 3, 2004

~~Specification~~

CIRCUIT SUBSTRATE FOR PACKAGING SEMICONDUCTOR DEVICE, METHOD FOR PRODUCING THE SAME, AND METHOD FOR PRODUCING SEMICONDUCTOR DEVICE PACKAGE STRUCTURE USING THE SAME

TECHNICAL FIELD

[0001] The present invention relates to a circuit substrate to ~~be~~ have mounted ~~with~~ thereon a semiconductor device and a method of producing the same. The invention also relates to a method of mounting a semiconductor device, with use of such a circuit substrate.

BACKGROUND ART

[0002] As one of techniques for mounting semiconductor devices on a circuit substrate, a flip chip mounting ~~methods~~ method has ~~have~~ been known. In ~~one of the methods~~ this method, bump electrodes are formed on a surface of a semiconductor chip on the same side ~~as the function~~ that a functional element thereof is formed, and the bump electrodes are connected through an adhesive layer to input/output terminal electrodes arranged on a circuit substrate. In this method, the bump electrodes are formed of gold (Au), nickel (Ni) or the like by plating, and for ~~the~~ an adhesive layer solder, conductive organic adhesive or the like is used. As the conductive organic adhesive, an anisotropic conductive film or paste, or the like ~~are~~ is used besides an isotropic adhesive.

[0003] Although ~~Solder~~ solder paste and isotropic conductive adhesive require little load for ~~the~~ connection in packaging, an anisotropic conductive film and an anisotropic conductive paste ~~require~~ are required to be loaded ~~on the level of~~ to at least 200 g per pin ~~at the maximum in~~ during packaging processes in order to secure stability of conductivity and reliability.

[0004] ~~Fig. 16 shows~~Figs. 16A and 16B show an example of a conventional flip chip mounting technique using an anisotropic conductive resin film (see Isao Tsukagoshi et al; "Electronics Jisso Gijutsu," 1997 March, p. 46-49, Gijutsu Chosakai Co., Ltd.). In this method, terminal electrodes of a semiconductor substrate are bonded to terminal electrodes of a circuit substrate by ~~means~~ virtue of an anisotropic conductive resin film. The anisotropic conductive resin film contains epoxy resin conductive particles, such as Ni metal particles or Au-coated resin particles, as main ingredients of an adhesive. ~~In~~ During assembly, the circuit substrate and the semiconductor device are heated under a load and the conductive resin film is interposed and pressed between the electrodes, so that the conductive particles in the resin film are brought into contact with one another to achieve ~~all the electric~~ electrical connections between all the electrodes facing each other.

[0005] Japanese Patent Publication 8-037206 discloses a method of semiconductor device packaging in which, as shown in Figs. 17A to 17D, a conductive adhesive sheet 91 being in B-stage is interposed between dies 92, 92 and punched ~~out~~ by a punch 93 (Fig. 17A) into small pieces 94 of the conductive adhesive sheet, each which ~~are~~ is aligned with and bonded to a corresponding pad electrode 2 on a circuit substrate 1 so as to be used as an adhesive layer (Fig. 17B). On the other hand, ball bumps 73 are formed on electrode pads 61 of a semiconductor chip 5 (Fig. 17C). ~~In~~ During mounting, the ball bumps 73 on the semiconductor chip 5 are heated and bonded to ~~the~~ corresponding small pieces 94 of the conductive adhesive sheet on the circuit substrate 1 so that each of the ball bumps is connected to ~~the~~ a corresponding electrode (Fig. 17D).

[0006] Japanese Patent Publication 10-199932 discloses a method for packaging a semiconductor device in which electrically conductive and plastically deformable bumps are formed on a large number of pad electrodes on a semiconductor chip, are leveled in a height direction, and ~~such bump on the semiconductor device~~ are pressed ~~to~~ against and bonded to~~,~~ ~~the~~ corresponding pads on a circuit substrate. ~~When~~ To bond ~~bonding~~, adhesive is applied to

flat head planes of the leveled bumps which are joined to the corresponding pads.

[0007] In recent years, semiconductor devices have increasingly been required to ~~have high~~ be very compact, ~~compactness~~ and to be capable of performance for use in portable electronic equipment. In order to fulfill ~~the~~ these requirements, it is important that semiconductor devices to be mounted on, and interconnected ~~to~~ with, circuit substrates should be provided with an increased number of pins for input/output terminals with a much smaller pitch between ~~the~~ adjacent terminals, and that an area array of electrodes can be achieved in a zone where the electrodes can be arranged. This requires further development of techniques for achieving narrower-pitch connection.

[0008] ~~The~~ An area array arrangement of electrodes has been established by conventional solder bump methods. ~~The~~ A solder bump technique has ~~the~~ advantages in that stresses acting on ~~the~~ active elements on an integrated circuit chip ~~in~~ during mounting are relatively small, thereby allowing the integrated circuit chip to sustain no damage. However, ~~the~~ a diameter of solder bumps is so large that ~~the~~ an electrode arrangement for mounting with area array arrangement has been limited to ~~the~~ an electrode pitch of about 250 μm, if necessity of miniaturizing ~~the~~ processes of substrates and package reliability are considered.

[0009] The above heat-press bonding technique using an anisotropic conductive adhesive has been noted from the viewpoint of production efficiency improvement for cost reduction, because productivity ~~in the~~ of a packaging process is expected to be higher than ever ~~has been expected~~.

[0010] In the above heat-press bonding method using an anisotropic conductive resin film, by pressing the conductive resin film between each of ~~the~~ bump electrodes on ~~the~~ a semiconductor ~~chip~~ substrate and ~~the~~ corresponding ~~bump electrode~~ input/output terminal electrodes on ~~the~~ a circuit substrate, ~~the~~ conductive particles are brought into contact with one another to impart electrical conductivity between the bump ~~electrode~~ electrodes on the semiconductor ~~chip~~ substrate and ~~the~~ corresponding ~~bump electrode~~ input/output terminal

electrodes of the circuit substrate. For providing ~~the~~ connection between the electrodes, a considerably large load between the electrodes ~~in~~ during mounting is required to be, for example, not less than 200 g per bump electrode. This force may damage a semiconductor circuit or may cause failures, or breakage, of Al interconnections on the semiconductor substrate.

[0011] In packaging by using this method, the ~~whole~~ conductive resin in its entirety is cured while the semiconductor substrate is being pressed with a large force so as to be brought into direct contact with the input/output terminal electrodes of the ~~circuit~~ substrate, so that stress ~~taking place~~occurring between ~~the~~ electrodes facing each other produces residual stress within the semiconductor substrate, ~~therefore,~~ thereby reducing ~~the~~ performance of ~~the~~ a semiconductor circuit. In particular, pressure ~~exerting~~ exerted on the bump electrodes at ~~the~~ a time of mounting may cause the input/output terminal electrodes of the circuit substrate to be deformed into fracture ~~in~~ during via hole filling ~~in~~ of the substrate connected to the electrodes, resulting in faulty connections in the circuit substrate.

[0012] This may happen because, in ~~the~~ a case of an anisotropic conductive resin, conductive particles contained in the anisotropic conductive ~~film~~ resin and silica filled therein for controlling a thermal expansion coefficient can stress a surface on ~~the~~ a side of ~~the~~ a semiconductor functional part of the semiconductor ~~chip~~ substrate due to pressure during packaging.

[0013] In the packaging technique disclosed in Japanese Patent Publication No. 8-037206, there has been a problem in that ~~the~~ bonding of a large number of ball bumps to ~~the~~ adhesive layers reduces reliability because ~~the~~ small pieces of ~~the~~ a conductive sheet punched from a conductive adhesive sheet must be handled. While loads ~~in~~ during packaging are partially applied only to the vicinity of the electrodes, ~~therefore,~~thereby reducing damage to ~~the~~ a semiconductor device, an increase in ~~the~~ pressure for ensuring ~~the~~ bonding may cause a risk ~~to destruct~~ with regard to destructing via holes beneath ~~the~~ pad electrodes on a circuit

substrate because ~~the~~ bump electrodes apply pressure to the pad electrodes ~~on the circuit substrate~~ and stress the pad electrodes. Another problem is that the conductive adhesive sheet is very weak in terms of adhesive strength for joining the semiconductor device to the circuit substrate, thereby resulting in reducing reliability of ~~the~~ a semiconductor package.

[0014] In the above method of Japanese Patent Publication No. 10-199932, adhesive is applied to tops of ~~the~~ bumps on ~~the~~ a semiconductor chip and then the bumps are joined to surfaces of ~~the~~ pads, resulting in unevenness in height of the bumps which causes faulty bonding; therefore, in order to improve reliability of ~~all the adhesions~~ adhesion between ~~the~~ all opposing electrodes, the bumps are required to be previously leveled in height. Though the ~~pressing~~ bumps might be deformed so as to collapse and bonding could be thereby reinforced, there is a danger that such a deformation might result in damage to the semiconductor chip as described above.

~~DISCLOSURE~~ SUMMARY OF THE INVENTION

[0015] It is an object of the present invention to provide a circuit substrate, which is to constitute a package structure ~~of~~ by mounting a semiconductor device thereon, which allows connections between electrodes without exerting stress to electrodes or degrading ~~in~~ characteristics of the semiconductor device ~~when packaging~~ while being mounted onto the circuit substrate.

[0016] It is another object of the invention to provide a method for allowing connections between electrodes without development of residual stress between these electrodes when mounting a semiconductor device ~~on the~~ onto a circuit substrate, and a method of producing such a package structure.

[0017] The circuit substrate of the invention includes conductive resin adhesive layers (portions) which are bonded ~~onto~~ to input/output electrodes, respectively, on a surface of the circuit substrate ~~for connection between electrodes~~, and a resin film that has previously

covered the surface of the substrate including the conductive resin adhesive layers. Bump electrodes corresponding to ~~those~~ these input/output electrodes, having pointed heads, are formed on electrodes of a semiconductor ~~chip~~ device.

[0018] When the semiconductor device is mounted ~~on~~ onto the circuit substrate, the bump electrodes of the semiconductor device are pressed toward the input/output electrodes on the circuit substrate such that the ~~sharp~~ pointed heads of the bump electrodes pierce the resin film on the circuit substrate and reach ~~the~~ respective conductive adhesive layers. The conductive adhesive layers receive the bump electrodes, ~~connect~~ attach fixedly thereto ~~fixedly~~, and relax stresses to be ~~developed~~ applied to the semiconductor device by the bump electrodes, which avoids damaging semiconductor circuits and interconnections on the semiconductor device. Even if the heads of some of the bump electrodes do not reach the ~~pad~~ input/output electrodes because of warp in the circuit substrate or unevenness in height of the pointed heads, the pointed heads are received within the conductive adhesive layers so that ~~electric~~ electrical connection between ~~the~~ opposing electrodes can be secured by conductivity of the conductive adhesive layers.

[0019] In the present invention, the resin film serves also as a protective coating which protects the ~~pad~~ input/output electrodes ~~for~~ of the circuit substrate. For ~~the~~ a package structure, the resin film has a function of supporting and reinforcing connection regions, including the bump electrodes and the conductive adhesive layers, to integrally join ~~the~~ a surface of the circuit substrate to a surface of ~~the~~ a semiconductor circuit, thus ensuring ~~electric~~ electrical and mechanical reliability of the package structure and enabling heat-press packaging that is suitable for ~~a~~ high productivity .

[0020] The package structure of the present invention is capable of preventing degradation in characteristics of a semiconductor functional part, and failures such as breaks in ~~interconnection~~ interconnections that have been problems with conventional anisotropic conductive films, because the conductive adhesive ~~relaxes~~ layers relax stress during

packaging. Besides, use of conductive adhesive layers allows mounting with a low load, because such a mounting load ~~as~~ that deforms the ~~pad~~ input/output electrodes of the circuit substrate is not required. Moreover, addition of conductive adhesive layers having a flexible nature into a junction layer leads to provision of ~~the~~ a package structure that is more reliable than conventional structures. The package structure can be ~~applied as~~ assembled with heat-press bonding mounting with ~~a~~ high productivity and ~~a~~ low cost that causes no damage, in contrast to typical package structures for an integrated circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Fig. 1A shows a schematic cross-sectional view of a circuit substrate according to an embodiment of the invention;

[0022] Fig. 1B shows a schematic cross-sectional view of a multilayered circuit substrate according to ~~the~~ an embodiment of the invention;

[0023] Fig. 2A shows an arrangement of ~~the~~ a circuit substrate and a semiconductor device ~~in~~ during a ~~producing~~ production process according to ~~a~~ an embodiment of the invention;

[0024] Fig. 2B shows a package structure for the semiconductor device in a state where the circuit substrate and the semiconductor device shown in Fig. 2A have been assembled;

[0025] Figs. 3A to 3D show processes of producing ~~the~~ a circuit substrate according to an embodiment of the invention, in schematic cross sectional ~~view~~ views;

[0026] Figs. 4A to 4D show processes of ~~another method of~~ producing ~~the~~ a circuit substrate according to another embodiment of the invention, in schematic ~~sections~~ cross-sectional views;

[0027] Figs. 5A to 5H show processes ~~of a method~~ of producing ~~the~~ a circuit substrate according to still another embodiment of the invention, in schematic cross-sectional views

~~sections~~;

[0028] Fig. 6A shows a schematic cross-sectional view of a package structure according to an embodiment of the invention;

[0029] Fig. 6B shows a schematic cross-sectional view ~~section~~ of a resin film for a circuit substrate used in the package structure of Fig. 6A;

[0030] Fig. 6C shows a schematic cross-sectional view illustrating a process of assembling the package structure of Fig. 6A with use of the resin film shown in Fig. 6B;

[0031] Fig. 7A shows an arrangement of ~~the~~ a resin film for a circuit substrate, the circuit substrate, and a semiconductor device ~~in~~ during a ~~producing~~ production process according to ~~the~~ an embodiment of the invention;

[0032] Fig. 7B shows ~~the~~ a package structure assembled with use of the circuit substrate and the resin film of Fig. 7A, in a schematic cross-sectional view~~section~~;

[0033] Fig. 8A shows an arrangement of a circuit substrate and a semiconductor device ~~in~~ during a ~~producing~~ production process in accordance with an embodiment of the invention;

[0034] Fig. 8B shows a package structure assembled with use of the circuit substrate of Fig. 8A, in a schematic cross-sectional view;

[0035] Fig. 9A shows an arrangement of a circuit substrate and a semiconductor device ~~in~~ during a ~~producing~~ production process in accordance with ~~the~~ an embodiment of the invention, and Fig. 9B shows a package structure that has been assembled with use of the circuit substrate of Fig. 9A, in a schematic cross-sectional view~~section~~;

[0036] Fig. 10 is a schematic cross-sectional view of a package structure in accordance with ~~the~~ an embodiment of the invention;

[0037] Fig. 11 is a schematic cross-sectional view of a package structure used in an embodiment of the invention;

[0038] Fig. 12A is a graph showing ~~the relation~~ relationships between mounting load

and connection resistance in ~~the~~ an embodiment of the invention;

[0039] Fig. 12B is a graph showing changes in connection resistance with respect to temperature in the embodiment corresponding to Fig. 12A;

[0040] Fig. 12C is a graph showing ~~relations~~ relationships between heating-cooling cycle and stability of connection resistance in the embodiment ~~of the invention~~ corresponding to Fig. 12 A;

[0041] Figs. 13A to 13E are metallographical photographs, each showing a metal section of a connection part between a bump electrode and a conductive adhesive layer in ~~the~~ an embodiment in which a glass epoxy substrate was used as a circuit substrate, and in which connection was made with a mounting load varied as a parameter;

[0042] Fig. 13F shows a photomicrograph of a metal section of a connection part between a bump electrode and a conductive adhesive layer in ~~the~~ an embodiment in which a glass ceramic substrate was used as a circuit substrate;

[0043] Fig. 14A shows ~~relations~~ relationships between all-series resistance of all connection portions in an embodiment of the invention and repeated heat cycles in a solder heat test;

[0044] Fig. 14B shows temperature dependency of all-series resistance in a test on ~~the~~ a connection part in the embodiment of the invention corresponding to Fig. 14A;

[0045] Fig. 14C shows ~~relations~~ relationships between number of heating-cooling cycles in a temperature cycling test and connection resistance in the connection part in the embodiment of the invention corresponding to Fig. 14A;

[0046] Fig. 15 is a metallographical photograph of a metal section of a junction of a package structure in which mounting has been executed with use of conductive adhesive and a resin film of the invention;

[0047] Fig. 16A shows an arrangement of a circuit substrate and a semiconductor device ~~in~~ during mounting with use of a conventional anisotropic conductive film;

[0048] Fig. 16B shows a package structure that has been assembled as shown in Fig. 16A, in a schematic ~~section~~ cross-sectional view; and

[0049] Figs. 17A to 17D are schematic ~~sections~~ cross-sectional views showing a method of mounting a semiconductor device in accordance with ~~a~~ prior art.

~~BEST MODE FOR CARRYING OUT THE INVENTION~~ DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0050] ~~The~~ A circuit substrate of the present invention is a circuit substrate to ~~be~~ have mounted ~~with~~ thereon a semiconductor device~~, comprising~~. The circuit substrate comprises input/output terminal electrodes formed on a surface ~~thereof~~ of a main body of the substrate, conductive adhesive layers (portions) attached to the terminal electrodes, and a resin film formed on the surface of the main body of the substrate so as to cover the terminal electrodes and the conductive adhesive layers.

[0051] Such a circuit substrate may be produced as follows. Conductive adhesive ~~may be~~ is applied by printing the adhesive onto ~~the~~ input/output terminal electrodes formed on ~~the~~ a surface of a main body of the substrate, and the conductive adhesive layers ~~can be~~ are thereby formed. After the conductive adhesive layers are cured, the surface of the main body of the substrate is coated with ~~the~~ a resin film so that the film covers the conductive adhesive layers together with the terminal electrodes.

[0052] The circuit substrate of the invention is used ~~in order~~ such that a semiconductor device may be mounted on the circuit substrate for producing ~~the~~ a package structure of the semiconductor device. In the package structure, bump electrodes on the semiconductor device are electrically connected through the conductive adhesive to the input/output terminal electrodes on the main body of the circuit substrate, and the semiconductor device is bonded and fixed to the circuit substrate by the resin film which has previously been formed on the main body of the circuit substrate.

[0053] At ~~the~~ a time such a package structure is assembled, the bump electrodes ~~having~~ have pointed heads that have previously been formed on input/output electrodes of the semiconductor device, and ~~, on the other hand,~~ the circuit substrate is provided with ~~the~~ its input/output terminal electrodes on the surface of the main body of the circuit substrate~~, the~~. The conductive adhesive layers ~~applied onto the~~ are formed on these terminal electrodes, and ~~a~~ also formed is the resin film covering the surface of the main body of the substrate and the conductive adhesive layers. The package structure is assembled and produced as follows. The semiconductor device ~~are~~ is pressed to the circuit substrate so as to insert the bump electrodes into the resin film, after the film has been melted on the circuit substrate ~~that has been heated and to be fixed~~ through heating, such that the bump electrodes become fixed to ~~the~~ respective conductive adhesive layers~~, and then~~. Then, the bump electrodes are electrically connected to ~~the~~ corresponding terminal electrodes of the circuit substrate before the resin film is cured so as to join the semiconductor device to the circuit substrate.

[0054] In the present invention, at ~~the~~ a time of packaging, the conductive adhesive layers, which comprise composite material containing conductive particles dispersed in high density in a resin component, have already been heated, thereby remaining softened. When ~~fitter~~ fitted onto the terminal electrodes on the main body of the circuit substrate, the bump electrodes having the pointed heads on the semiconductor device have only to reach the softened conductive adhesive layers, but do not require so high a pressure as ~~deforms~~ to deform the electrodes of the circuit substrate, i.e., the semiconductor device can be joined to the circuit substrate even with a low mounting load. The conductive adhesive layers of ~~on~~ the circuit substrate ~~receives~~ receive the bump electrodes, ~~deforms itself~~ and deform to lessen stress which is to be developed by ~~the~~ such reception, and therefore prevents residual stress from remaining in the semiconductor device. As a result, degradation in characteristics of the semiconductor device, breaks in interconnection, and the like can be effectively prevented ~~effectively~~.

[0055] Moreover, the circuit substrate may originally be provided with the conductive adhesive layers on the electrodes on the surface of the main body of the circuit substrate, and with the resin film (film) which fully covers the surface of the main body of the substrate together with the conductive adhesive layers so that the semiconductor ~~devices~~ device can be packaged by performing one procedure of heat-press bonding, thus achieving a packaging operation at a low cost.

[0056] The conductive adhesive may be prepared by kneading a pasty mixture of a resin component and conductive particles as conductive filler. When used, the adhesive is coated, in a thin ~~lyaer~~layer, ~~to~~ onto a top surface of each of the input/output terminal electrodes (i.e., pad electrodes) on the main body of the circuit substrate to form the conductive adhesive ~~layer~~ layers.

[0057] The resin component of the conductive adhesive may be selected from thermoplastic resins and thermosetting resins, and epoxy resin may preferably be ~~preferably~~ used in ~~viewpoints~~ view of stability~~,~~ and electric insulation, especially~~,~~ high-frequency performance~~,~~ and strength, ~~especially,~~ and high heat resistance. The resin component is solid at ordinary temperatures, and preferably, may be suitably softened or melted when being moderately ~~heating in~~ heated during a mounting operation.

[0058] As the conductive particles, there can be used particles formed of a metal selected from noble metals of Cu, Ag, and Au, ~~the~~ an iron group of Fe, Ni and Co, ~~the~~ a platinum group of Pt, Pd, et al, and other metals such as Zn, and carbon C. Resin particles coated with metal ~~on surfaces thereof~~, such as Au-coated resin particles, also can be used.

[0059] On the other hand, the resin film is made of a resin selected from among thermosetting resins which, ~~in the~~ during a mounting operation, can be softened or melted under moderate heat applied to the ~~whole~~ circuit substrate in its entirety. As such a resin, for example, thermosetting epoxy resin, silicone resin, urethane resin, polyvinyl chloride resin, phenolic resin, acrylic resin, polyester, polycarbonate, and polyacetal can be used, and

particularly, epoxy resin may be preferable.

[0060] The resin film may further contain a powdery filler that is suitable for viscosity control, an expander or reinforcement. As the filler, for example, there can be used inorganic particles such as silica SiO_2, alumina Al_2O_3, silicon nitride Si_3N_4, silicon carbide SiC, and aluminum nitride AlN. In this case, the resin film exhibits insulation.

[0061] It is preferable for such conductive adhesive layers, on the electrodes, to have a thickness of not greater than 10 μm ~~on the electrodes~~, and it is particularly preferable for the layers to have a thickness on the order of 0.1 to 3 μm.

[0062] The resin film may contain conductive particles as the filler, ~~the~~ with these conductive particles being used, for example, ~~as~~ for an anisotropic conductive resin film containing suitable metal particles. In this case, the resin film has only to be insulating under no load or pressure ~~in the~~ during mounting, even when the resin film is sandwiched between ~~the~~ electrodes. ~~Electric~~ Electrical connections between the electrodes ~~can be~~ is provided by the conductive adhesive layers that are separately provided on the electrodes of the circuit substrate.

[0063] Figs. 1A and 1B show schematically a ~~schematically~~ cross-sectional view of a circuit substrate ~~1~~. Input/output terminal electrodes 2 are formed on a surface of a main body 1 of the circuit substrate ~~1~~, and, in this example, the terminal electrodes 2 have flat top surfaces on which conductive adhesive layers (portions) 3 are formed. A resin film 4 is attached and adheres to ~~the whole~~ an entire surface of the main body 1 of the circuit substrate ~~1~~, in this example, so as to cover the conductive adhesive layers 3 and the input/output terminal electrodes 2 (pad electrodes). Fig. 1A shows an example of a single-layer resin substrate and Fig. 1B shows an example of application to a multilayered resin substrate. In the substrate ~~1~~ of this example in Fig. 1B, there are arranged three resin insulating layers 11a, 11b, and 11c, and interlayer electrodes 13 having specified patterns ~~and~~ interposed between the insulating layers~~, and the upper~~. Upper and lower interlayer electrodes are connected by

conductors, i.e., via conductors 14, formed through the insulating layers 11a, 11b, and 11c. ~~The via~~Via conductors 15 on ~~the~~ a top surface are connected to the pad electrodes 2 on the surface, and electrodes 12 for interconnection are provided on a lower surface of the resin insulating layer 11c, i.e., ~~the~~ a lowermost layer.

[0064] Fig. 2A shows a process of packaging a semiconductor device 5 on the circuit substrate ~~1~~, and Fig. 2B shows a package structure in which the semiconductor device 5 has been joined to the circuit substrate ~~1~~.

[0065] In the semiconductor device 5 of this example in Fig. 2A, a semiconductor functional part ((not shown) e.g., an integrated circuit portion) and a large number of input/output terminal electrodes 6 (pad electrodes) connected to the semiconductor functional part are formed on a surface of a semiconductor substrate 50, and projection electrodes 7 (bump electrodes) having pointed heads are formed on ~~the~~ these terminal electrodes.

[0066] As described above, the circuit substrate ~~1~~ to receive the semiconductor device 5 is originally formed with conductive resin adhesive layers 3 positioned on the input/output terminal electrodes 2 on the surface of the main body 1 of the circuit substrate ~~1~~, corresponding to the bump electrodes 7 of the semiconductor device 5, and with a resin film 4 which covers the main body 1 of the ~~whole~~ circuit substrate ~~1~~.

[0067] ~~In the~~During a mounting operation, the semiconductor device is sucked by a heated head ~~heated~~ of a mounting machine, that is provided with a heater, and is heated and pressed to the circuit substrate so that the bump electrodes 7 are inserted into ~~the~~ corresponding conductive adhesive layers 3 ~~on~~ of the substrate, and later, the semiconductor device is cooled. The bump electrodes 7 are thereby bonded to the conductive adhesive layers 3, and the semiconductor substrate 50 of the semiconductor device is bonded and fixed ~~onto~~ to the circuit substrate ~~1~~ by the resin film 4. In this process, the circuit substrate also may be ~~preferably~~ heated such that the conductive adhesive 3 and the resin film 4 are softened.

[0068] Fig. 2B shows the package structure in which the semiconductor device 5 has

been mounted on the circuit substrate ~~1~~. In this structure, the conductive adhesive layers 3 ~~on~~ of the circuit substrate receives the bump electrodes 7 of the semiconductor device 5, and bonds and fixes the bump electrodes 7 ~~by~~ via a bonding effect of the adhesive layers. Further, the resin film 4 having covered the surface of the main body of the substrate now fills a gap between the circuit substrate ~~1~~ and the semiconductor device 5, which bonds the circuit substrate ~~1~~ to the semiconductor device 5 and ~~to fix both~~ stably fixes the circuit substrate relative to the semiconductor device.

[0069] This circuit substrate ~~1~~ as described above, configured by formation of the adhesive layers on the ~~surface~~ input/output terminal electrodes 2 of the substrate, and by coating of the resin film 4 thereon, may be formed as follows. ~~Input/output~~ The input/output terminal electrodes 2 (pad electrodes) have previously been formed on the surface of the main body of the circuit substrate so as to correspond accurately to the input/output terminal electrodes 6 of the semiconductor device 5 and, ~~in~~ during a process of forming the conductive adhesive layers 3, conductive adhesive is preferably applied by a printing process onto the input/output terminal electrodes 2 formed on the surface of the main body of the substrate. Alternatively, conductive adhesive transferred onto the bump electrodes 7 of the semiconductor device may be transferred again onto the input/output terminal electrodes of the circuit substrate.

[0070] For the printing process of forming the adhesive layers, Figs. 3A and 3B show an example using screen printing. The printing process includes preparation of paste 30 of a conductive adhesive from a liquid resin component and ~~conductor~~ conductive particles (e.g., silver particles), and a required viscosity modifier or the like. As shown in Fig. 3A, a screen mask 8 is positioned with respect to the terminal electrodes 2 ~~on~~ of the circuit substrate ~~1~~ so as to mask ~~other portion~~ portions of the main body of the substrate but not ~~than~~ the terminal electrodes 2, and the paste 30 is developed on the screen mask 8 by a squeegee 82 so as to be applied only onto the terminal electrodes 2 in a required thickness. The conductive adhesive

layers 3 are thereby applied ~~on~~ onto the terminal electrodes 2 as shown in Fig. 3B, and are subsequently cured. If a solvent-type adhesive is used as a conductive adhesive, the adhesive can be cured by volatilizing the solvent therein.

[0071] In a subsequent resin film coating process, a thermosetting resin film 40 may be used, which has previously been formed, for the resin film and which has an appropriate adhesive property, in which case, as shown in Fig. 3C, the resin film 40 is heated to be softened and is bonded onto the surface of the main body of the substrate so as to cover both the conductive adhesive layers and the terminal electrodes 2 ~~thereon~~. The resin film 40 is heated ~~to~~ such that a surface of the resin film 40 sticks to the surface of the main body of the substrate for bonding. As a result of this process, as shown in Fig. 3D, the circuit substrate ~~1~~ can be obtained on which the conductive adhesive layers and the resin film 4 are stacked.

[0072] For ~~the~~ bump electrode 7 of the semiconductor device a structure can be used which has a projecting portion 70 at an extremity thereof, and is capable of piercing the resin film 4 and ~~the~~ conductive adhesive layer 3. For example, there can be used projected conductive electrodes ~~7~~ made with use of a wire bonding method, or projected electrodes ~~7~~ formed with use of an electroplating or electroless plating method. In particular, ~~projection~~ projected electrodes shaped by plucking away molten metal using ~~the~~ a wire bonding method may be used as the bump electrodes 7, and, ~~in~~ during a mounting operation, ~~the~~ a pointed head of each of the bump electrodes can produce an increased force to pierce into the resin film 4 at ~~the~~ a time of mounting, thereby providing stable connections between the electrodes 2 and 7 by pressing with a ~~lower~~ low load ~~to the substrate~~. For such bump electrodes, for example, a low-melting metal or alloy thereof, containing Au, Sn, Ag, Pb, Bi, Zn, Sb, Pd, C, Pt, or the like may be used. The pointed heads of the bump electrodes preferably may have a rectangular, circular, or elliptical shape, with a size of one side or a diameter of an extremity thereof being not greater than about 20 μm. It is particularly preferable for the size of ~~the~~ each pointed ~~heads~~ head to be not greater than 10 μm.

[0073] Another method of producing the circuit substrate may include ~~the~~ steps of: previously forming ~~the~~ conductive adhesive layers 3 on ~~the~~ separate resin film 40 as described above to prepare ~~the~~ resin film 4; covering the main body of the circuit substrate with the resin film 40 ~~for the~~ such that the conductive adhesive layers ~~to~~ face ~~the~~ input/output terminal electrodes 2 of ~~the~~ circuit substrate 1; and bonding the resin film to the main body of the circuit substrate. In order to form the conductive adhesive layers 3 on the resin film 40, there can be used a method of applying conductive adhesive paste 30 onto ~~the~~ a thermoplastic resin film by performing a printing process with a pattern corresponding to an arrangement of the terminal electrodes 2 on the main body of the circuit substrate ~~1~~.

[0074] In Fig. 4A, a separate resin film 40 is coated with conductive adhesive paste 30 in a specified thickness, by printing with use of ~~the~~ printing screen mask 8 and ~~the~~ squeegee 82. The conductive adhesive paste applied may preferably be cured. Patterned conductive adhesive layers 3 are thereby formed on the resin film 40 as shown in Fig. 4B.

[0075] As shown in Fig. 4C, the resin film 40 having the conductive adhesive layers 3 thereon is bonded onto the main body 1 of the circuit substrate ~~1~~ such that the conductive adhesive layers 3 accurately oppose ~~to the~~ respective input/output terminal electrodes 2 on the main body of the circuit substrate and cover the terminal electrodes 2. For bonding, the resin film 40 is heated to such an extent that a surface of the resin film ~~is sticking~~ adheres to the main body 1 of the circuit substrate. Thus, this process, as shown in Fig. 4D, can provide ~~the~~ a circuit substrate ~~to~~ with which the conductive adhesive layers 3 and the resin film 4 are integrated.

[0076] Another method of forming ~~the~~ conductive adhesive layers 3 on ~~the~~ resin film 40, as shown in Figs. 5A to 5F, when preparing ~~the~~ resin film 4, may include: ~~bonding~~ initially bonding a masking sheet 81 onto a resin film 40; and boring through holes 85 ~~with~~ of a specified pattern through the bonded masking sheet 81 to form a mask ~~8~~.

[0077] In this method, the through holes 85 are bored through the masking sheet 81

so as to coincide with positions on the resin film 40 that are to correspond to ~~the~~ terminal electrodes 2 on the main body 1 of the circuit substrate ~~1~~. The through holes 85 end at a surface of the ~~substrate~~ resin film 40 that ~~makes~~ defines bottom surfaces ~~thereof~~ of the through holes, and are filled with conductive adhesive paste 30. After ~~the~~ this filling, only the masking sheet 81 is removed. With ~~the~~ removal of the masking sheet 81, the paste 30 that has filled the through holes 85 remains as the conductive adhesive layers 3, with a desired pattern, on the ~~circuit substrate~~ resin film 40. The masking sheet 81 is preferably composed of two layers, i.e., a separate resin sheet 84 to be bonded onto the resin film 40, and a release sheet 83 that adheres ~~onto~~ to the sheet 84. The through holes are formed so as to pierce the resin sheet 84 and the release sheet 83. The masking sheet composed of two layers has an advantage ~~in~~ of improving formability of conductive adhesive, for the following reason. At ~~the~~ a time of filling, ~~the~~ some of conductive adhesive paste 30 ~~is left also~~ remains on the release sheet 83 outside of the through holes, and there is a fear that the conductive adhesive paste inside the through holes might be exfoliated and removed simultaneously with ~~the~~ removal of the resin sheet 84 if the paste that has overflowed the through holes is cured. If only the release sheet 83 can immediately be stripped off while the paste ~~being~~ is in a soft state after filling, however, conductive adhesive can be reliably and fully fed only into the through holes and the cured resin sheet 84 has only to be stripped off afterward.

[0078] In the method of producing the circuit substrate ~~1~~, which is shown in Figs. 5A to 5H, in detail, the separate resin sheet 84 and the release sheet 83 stacked on the sheet ~~48~~ 84 are initially bonded, as the masking sheet 81, onto the resin film 40, as shown in Fig. 5A. Because the resin film 40 is to be ~~the~~ resin film 4 when the resin sheet 84 and the release sheet 83 are later removed ~~later~~, ~~those are used~~ materials chosen for the release sheet 83 and resin sheet 84 are ones which can easily be separated from the resin film 40. For the release sheet 83, Teflon, cellophane, polyethylene terephthalate), silicone, or the like, may be used, which is non-adhesive and ~~have~~ has a releasable property. For the resin sheet 84 may be used,

for example, a resin soluble in acid or alkali, such as polyacetal, polycarbonate, epoxy resin, phenolic resin and polyester.

[0079] In ~~the~~ a next step, as shown in Fig. 5B, the through holes 85 through the resin sheet 84 and the release sheet 83, both stacked on the resin film 40, are accurately positioned relatively to the corresponding terminal electrodes 2 provided on the main body 1 of the circuit substrate ~~1~~. The resin sheet 84 and the release sheet 83 are scanned with a laser beam, and positions therein corresponding to the terminal electrodes 2 are illuminated with the laser beam so as to be heated and melted ~~so~~ such that the through holes 85 are ~~opened and~~ formed.

[0080] The through holes can be formed by ultraviolet irradiation instead of ~~the~~ laser irradiation. In an ultraviolet irradiation method, a resin sensitive to ultraviolet rays is used. As the resin for this purpose, ultraviolet curing epoxy or acrylic resin can be preferably used ~~preferably~~. When portions ~~to be opened~~ of uncured release sheet 83 are masked for interception of rays of light and the sheet is irradiated with ultraviolet rays in this method, portions of the ~~resin~~ sheet other than the masked portions are cured, whereas ~~the~~ portions to be ~~opened~~ removed directly under ~~the~~ an intercepting mask remain uncured. Then, removal of the uncured portions results in formation of the through holes.

[0081] In ~~the~~ a next step, as shown in Figs. 5C and 5D, paste 30 of a conductive adhesive is extended ~~on~~ onto the release sheet 83 with the squeegee 82, so that the through holes are filled with the paste. ~~The embedded~~ Embedded paste 30 of the conductive adhesive is then cured. If a solvent-type resin is used ~~in~~ as the conductive adhesive, the adhesive can be cured by vaporization of its solvent. After that, the release sheet 83 is pealed off as shown in Fig. 5E, and an acid-soluble resin of the resin sheet is removed, as shown in Fig. 5F, by acid treatment with hydrochloric acid, sulfuric acid or the like.

[0082] The resin film 40, thus having ~~the~~ patterned conductive adhesive layers 3, is bonded onto a main body of a circuit substrate as shown in Fig. 5G. For bonding, a method of heating the resin film 40 to within a temperature range is employed in which the resin film

is softened so as to adhere to ~~the~~ a surface ~~thereof~~ of the main body of the substrate. Thus, as shown in Fig. 5H, the circuit substrate ~~1~~ in which the conductive adhesive is integrated with the resin film 4 can be obtained.

[0083] In a package structure using the circuit substrate of the invention in which ~~the~~ bump electrodes of a semiconductor device are electrically and mechanically connected to input/output terminal electrodes 2 of the circuit substrate 1 through conductive adhesive, the semiconductor device ~~being~~ is bonded by a resin film 4 formed previously on the main body 1 of the circuit substrate ~~1, an~~. An elastomer layer, which is elastically softer than the resin film 4, or a sealing resin, may be interposed between the semiconductor device and the resin film 4.

[0084] In a method of producing the package structure, ~~the~~ semiconductor device 5 has ~~the~~ bump electrodes 7, ~~the~~ main body 1 of the circuit substrate has ~~the~~ input/output terminal electrodes 2 on ~~the~~ a surface thereof, and a separate resin film 4 is previously provided with conductive adhesive layers 3 corresponding to the terminal electrodes 2 on the main body of the circuit substrate ~~1~~, on one side of the film, and ~~with~~ an elastomer layer corresponding to the semiconductor device 5~~,~~ is provided on ~~the other~~ another side of the film.

[0085] In this embodiment, the circuit substrate ~~1~~ has a ~~substrate~~ main body 1 on which terminal electrodes 2 as described above are arranged, conductive adhesive layers 3 are on the terminal electrodes 2, a resin film 4 ~~covering~~ covers the conductive adhesive layers, ~~a~~ and an elastomer layer is provided on the resin film 4. The elastomer layer on the ~~circuit substrate 1~~ resin film 4 may be interposed between a semiconductor functional part of the semiconductor device 5 and the resin film 4 on the main body of the circuit substrate, ~~then~~ thus constituting a package structure.

[0086] As the elastomer layer, a layer of synthetic resin (including elastic synthetic rubber) may be used, which is softer and has a lower elasticity modulus than the resin film 4. In this arrangement, at least the semiconductor functional part of the semiconductor device 5

is protected by the elastomer layer. The elastomer layer absorbs and reduces a stress that acts through ~~the~~ rigid resin film 4, or an exterior impulsive force ~~from outside~~, and therefore prevents damage to and degradation in function of the semiconductor functional part, e.g., an integrated circuit portion on a semiconductor substrate 50.

[0087] The elastomer layer may preferably be a silicone ~~elastmer~~ elastomer layer ~~with~~ while ~~respect to the~~ resin film 4 is of epoxy.

[0088] Fig. 6A shows an example of a package structure having ~~the~~ elastomer layer 9, in which ~~the~~ bump electrodes 7 formed on ~~the~~ input/output terminal electrodes 6 (pad electrodes) of ~~the~~ semiconductor device 5 are connected and fixed to ~~the~~ terminal electrodes 2 of ~~the~~ circuit substrate 1 through ~~the~~ conductive adhesive~~; the peripheries~~. Peripheries of connecting portions between the electrodes 2 and 7 are reinforced by a resin film 4~~; the~~. The elastomer layer 9 is of silicone rubber and is provided between the resin film 4, which is of epoxy, and ~~the~~ a surface of the semiconductor device 5 on which a semiconductor functional part 51 is arranged~~; and the~~. The elastomer layer 9 isolates the resin film 4, which is rigid. This can thus reduce damage to the semiconductor functional ~~element~~ part 51 on the semiconductor device 5. Further, the conductive adhesive can relax stresses developed when packaging, and thereby avoid deteriorating characteristics of ~~the~~ elements and breaking interconnections.

[0089] Fig. 6B shows a resin film 40 used on a main body 1 of a ~~the~~ circuit substrate ~~1~~ for use in ~~the~~ a package structure, wherein the resin film has conductive adhesive layers 3 in a specified pattern on one ~~surfaces~~ surface thereof, and has an elastomer layer 9 fixed to ~~the other~~ another surface thereof. In this example, the elastomer layer 9 is positioned so as to face ~~the~~ a semiconductor functional part 51 of ~~the~~ semiconductor device 5 when it is incorporated into the package structure.

[0090] Figs. 6A and 6C show a process of assembling the package structure with use of the resin film 40, to which the elastomer layer 9 is attached, and show ~~the~~ a resultant

package structure. ~~In~~ During assembling, the conductive adhesive layers 3 on the one surface of the resin film are made to correspond to ~~the~~ terminal electrodes 2 on the main body 1 of the circuit substrate ~~1~~, and the semiconductor device 5 is placed correspondingly on ~~the other~~ another surface of the resin film 40 having the elastomer layer 9 so that the elastomer layer 9 is positioned on the semiconductor functional part 51. In a softened state of the resin film 40 during heating thereof, the semiconductor device 5 is pressed toward the circuit substrate ~~1~~ so that ~~the~~ bump electrodes 7 on ~~the~~ terminal electrodes 6 (pads) ~~6 may~~ pierce the resin film 40 and reach the conductive adhesive layers 3, thereby achieving electrical connections. The resin film 40 fills a space between the circuit substrate and the semiconductor device 5, ~~making~~ thereby placing the elastomer layer 9 pad onto the semiconductor device 5, and the resin film integrally bonds ~~integrally~~ the semiconductor device 5 ~~with~~ to the circuit substrate ~~1~~.

[0091] Figs. 7A and 7B show another example of assembly using ~~the~~ elastomer layer 9. In Fig. 7A, the elastomer layer 9 has previously been attached or bonded to ~~the~~ semiconductor device 5. In Fig. 7B, by pressing the semiconductor device 5 toward the circuit substrate ~~1~~ in the same manner as shown in Fig. 6C, ~~the~~ bump electrodes 7 of the semiconductor device 5 ~~is~~ are pierced into ~~the~~ resin film 40, thereby reaching ~~the~~ conductive adhesive layers 3, and further the resin film 40 presses the elastomer layer 9 to the semiconductor device 5 and integrates the semiconductor device 5 with the circuit substrate ~~1~~.

[0092] In a package structure of a third embodiment of the invention, a space between a circuit substrate and a semiconductor device may be filled with a liquid sealing resin together with ~~the~~ a resin film. In a method of producing such a circuit substrate ~~1~~, such liquid sealing resin may be used instead of the resin film, or with the resin film ~~on which the liquid sealing resin is applied~~ by being applied to the resin film.

[0093] ~~Using the~~The liquid sealing resin~~, a sealing resin~~ may be porous. ~~The existence~~ Existence of air bubbles in the sealing resin provides an advantageous structure in

that ~~the~~ a semiconductor device does not reduce much in a high-frequency property apparently because a dielectric constant of air is ~~apparently~~ lower than that of the resin. ~~such~~ Such a sealing resin may contain foaming components which generate air bubbles when ~~the~~ resin components react to be cured. After curing, the air bubbles generated in the liquid resin remain as pores~~,~~, such that the sealing resin ~~being~~ becomes porous. ~~A content~~ An amount of the air bubbles can be changed, for example, by controlling quantities of a reactive diluent and the like.

[0094] ~~In use of~~When using a liquid resin, as shown in Fig. 8A, a liquid sealing resin is coated or ~~dropped~~ dripped onto ~~the~~ resin film 4 ~~on the~~ of circuit substrate~~; the~~. A semiconductor device 5 is pressed toward the circuit substrate~~; the bump~~. Bump electrodes 7 then ~~is~~ are pierced into the resin film 4 to reach ~~the~~ conductive adhesive layers 3 and to make electrical connections ~~to the~~ with terminal electrodes 2, ~~becoming contact with~~ thereby contacting the liquid sealing resin residing on the resin film 4~~; and~~. And, the liquid sealing resin is filled ~~in~~ into a space between the circuit substrate ~~1~~ and the semiconductor device 5 to bond both the substrate and the device together after being cured. Fig. 8B shows ~~the~~ a package structure assembled in such a manner. The package structure shown in Fig. 8B exhibits an example ~~where~~ in which the liquid sealing resin is a foaming resin which contains co-existing air bubbles 44 ~~coexisting~~.

[0095] Figs. 9A and 9B show an example in which terminal electrodes 2 on a main body 1 of a circuit substrate are covered only with a liquid sealing resin, i.e. without using a resin film. In Figs. 9A and 9B, bump electrodes 7 on terminal electrodes (pads) of a semiconductor device 5 are connected to conductive adhesive on the terminal electrodes 2 of the circuit substrate ~~1~~, and the sealing resin is filled ~~in~~ into a space between the semiconductor device 5 and the circuit substrate~~1~~, which are thereby sealed.

[0096] Fig. 10 shows an example where air bubbles 44 are made to remain in a sealing resin filling a space between a semiconductor device 5 and a circuit substrate ~~1~~ so that

the resin is made porous. A package structure having such air bubbles 44 prevents a high-frequency property of the semiconductor device 5 from ~~reducing~~ being reduced. The ~~liquid~~ sealing resin contains ~~foaming~~ components ~~to foam~~ which are foamed when cured.

Embodiments:

[Embodiment 1]

[0097] Fig. 11 shows a schematic section of a package structure for a semiconductor device 5 used in a test that will be described below, i.e., ~~the~~ a structure in which bump electrodes of the semiconductor device 5 are mounted on input/output terminal electrodes of a circuit substrate, with junction layers between, and which structure is reinforced with a sealing resin.

[0098] In ~~embodiment~~ Embodiment 1, Au bumps formed as the bump electrodes by performing a wire bonding method were mounted on the input/output terminal electrodes of the circuit substrate through conductive adhesive as the junction layers, and ~~sealed~~ sealing with an epoxy sealing resin was executed.

[0099] In conventional example 1, Ni-Au electroless plated bumps were used as ~~the~~ bump electrodes, ~~and~~ solder was used as ~~the~~ junction layers, and an ultraviolet curing epoxy resin was used as ~~the~~ a sealing resin ~~were used~~.

[00100] In each of ~~the embodiment~~ Embodiment 1 and ~~the~~ conventional example 1, a package structure for an n-channel MOS transistor was produced, and deterioration of the transistor was examined by a change in threshold voltage.

[00101] In results of ~~the~~ a test, the n-channel MOS transistor of ~~the embodiment~~ Embodiment 1 exhibited a change in threshold voltage of not greater than 0.7% with respect to a mounting load of 1 g per bump.

[00102] In ~~the~~ conventional example 1 employing a conventional soldering method, by contrast, a threshold voltage of the n-channel MOS transistor changed by approximately 10%

in comparison with that ~~in~~ of an initial stage, after ~~the~~ mounting with a mounting load of 10 g per bump.

[00103] Other package structures for SRAM according to the embodiment of the invention were produced in the same manner under mounting loads of 1 g and 20 g per bump, and achieved ~~in~~ good connections after ~~the~~ mounting, with no bit error (0/228) occurring due to ~~the~~ a mounting operation.

[00104] In consideration of these results, it is found that, in the soldering method of ~~the~~ conventional example 1, the junction layers ~~has~~ have no component that is capable of relaxing a shrinkage stress which acts when the sealing resin is cured so that ~~the~~ this stress acts directly on ~~the~~ a semiconductor device and changes its threshold voltages. ~~On~~ To the ~~contrast~~ contrary, in the embodiment of the invention, soft conductive adhesive as junction layers can relax a curing shrinkage stress caused by the sealing resin, and therefore no stress acts on a semiconductor substrate of the semiconductor device, so that ~~the~~ a satisfactory result can be obtained. A result of stress analysis also indicates that ~~the~~ a package structure using ~~the~~ conductive adhesive layers 3 can hardly produce stress therein. Therefore, it should be understood that conductive resin adhesive is an effective component for ~~the~~ stress relaxation.~~,~~

[00105] As ~~an~~ a conventional example, tests of packaging a semiconductor device were conducted using a conventional anisotropic conductive film 49 shown schematically in Fig. 16A. Herein, bump electrodes of ~~the~~ a semiconductor device were Au bumps formed with use of a wire bonding method, and there were used two types of circuit substrates, i.e., one having a ceramic ~~substrate~~ main body and one having a glass-epoxy ~~substrate~~ main body (a glass-fiber-reinforced epoxy ~~substrate~~ main body, hereinafter the same) (FR4) ~~and the~~. The anisotropic conductive film ~~having~~ had a thickness of 70 μm and ~~containing~~ contained Ni filler with a diameter of 5 μm. ~~The packaging~~ Packaging tests were conducted in which a mounting load between the bump electrodes of the semiconductor device and each of the

circuit ~~substrate~~ substrates was varied within a range from 10 to 80 g per bump electrode.

[00106] Fig. 12A shows ~~relations~~ relationships between initial connection resistances per bump, after ~~the~~ mounting, and ~~the~~ bump loads. The connection ~~resistance includes electric~~ resistances include electrical resistances of ~~the~~ a terminal electrode of the circuit substrate and the Au bump of the semiconductor device, and an ~~electric~~ electrical resistance of the anisotropic conductive film. As for the circuit substrate having the ceramic ~~substrate~~ main body, an initial connection was not obtained unless a mounting load of not less than 80 g per bump was achieved. As for the circuit substrate having the glass epoxy ~~substrate~~ main body, ~~the~~ resistance was found to be unstable unless an initial load of not less than 40 g per bump was applied.

[00107] Fig. 12B shows a change in resistance with respect to temperature ~~in~~ for each sample, and ~~the~~ a resistance change for the circuit substrate having the glass epoxy ~~substrate~~ main body (FR4) was found to be stable with mounting loads of not less than 40 g per bump. Results of a heat shock test (a heat cycle in liquid phase is from –55 to 125°C) shown in Fig. 12C, however, were unstable with a mounting load of 40 g per bump and stable with a mounting load of 80 g per bump.

[00108] Figs. 13A to 13E are a series of photomicrographs obtained by microscopic observation in the vicinity of an electrode in a cross section of a package structure, in which loads for bonding varied from 5 to 40 g per bump, using a circuit substrate having a glass-epoxy ~~substrate~~ main body (FR4) ~~as a circuit substrate and~~. In each of these photographs, a pad electrode fixed to the main body of the circuit substrate is shown on ~~the~~ a lower side, and a bump electrode on ~~the~~ a side of a semiconductor chip is shown on ~~the~~ an upper side. These photographs indicate that deformation of the bump electrode was caused with mounting loads on the order of at least 15 g per bump ~~or larger~~.

[00109] Fig. 13F shows a photomicrograph of a cross section in ~~the~~ a case of using a circuit substrate having a ceramic ~~substrate~~ main body. This substrate ~~having~~ had rigidity,

and input/output terminal electrodes were not deformed even with a mounting load of 80 g per bump, but unstable initial connection might develop faulty connection under ~~the~~ a temperature characteristic of Fig. 12B.

Embodiment 2

[00110] Packaging tests were conducted with use of a circuit substrate of the invention. A circuit substrate having a glass-epoxy ~~substrate~~ main body (FR4) was used ~~as the circuit substrate~~, and the package structure shown in Figs. 2A and 2B was tested. An epoxy resin film having a thickness of 50 μm was attached ~~onto~~ to a surface of the main body of the circuit substrate, including top surfaces of input/output terminal electrodes.

[00111] As bump electrodes of a semiconductor device, Au bumps with a size of ~~the~~ its pointed head ~~of~~ being 20 square μm ~~square~~ were formed according to a wire bonding method. In ~~the~~ a mounting structure, ~~the~~ semiconductor device 5 had the bump electrodes on ~~the~~ a chip pressed ~~on~~ against and connected to the input/output terminal electrodes of the circuit substrate having the resin film previously bonded ~~thereto~~ to the main body thereof, and the structure was reinforced by sealing resin filled ~~in~~ into a space between the resin film and the chip. ~~The tests~~Tests were conducted with a variation of loads for pressing the ~~bumps~~ bump electrodes of the semiconductor device to the input/output terminal electrodes ~~on~~ of the circuit substrate.

[00112] ~~The~~ A package structure obtained was tested ~~on~~ regarding initial connection performance with respect to the mounting loads per bump, and ~~on~~ regarding connection performance after reflowing and, in addition, tests were made ~~of heating~~ when the structure was repeatedly heated five times at 270°C.

[00113] Table 1 shows ~~the~~ these test results. Samples having this package structure exhibited stable and good electrical and mechanical connection performance over all ~~the~~ connections between the bump electrodes of the semiconductor device and the ~~pad~~ terminal

electrodes, with ~~pressure with~~ loads of not lower than 20 g per bump being applied at ~~the~~ a time of ~~the~~ mounting.

Table 1

Mounting load (g/bump)	5	10	20	40
Connectability after mounting	Good	Good	Good	Good
Connectability after reflow (240°C)	Failure	Good	Good	Good
Solder heat test(five times at 270°C)	Failure	Failure	Good	Good

[00114] Fig. 14A shows a change in ~~the~~ resistance of ~~the~~ junction portions ~~in~~ at each stage of ~~the~~ solder heat tests. In the solder heat tests, samples with mounting loads of not lower than 20 g per bump show no change in junction resistance, even when heating is repeated ~~5~~ for five cycles at 270°C.

[00115] Fig. 14B shoes stable connection performance ~~in~~ with regard to temperature characteristics of ~~the~~ junction resistance, and it was found that a satisfactory result was obtained.

[00116] Fig. 14C shows a result of a repetition test between heating (+125°C) and cooling (-40°C) (temperature cycling test) run on eight samples having the ~~obtained~~ above package structure (~~united~~ produced with a mounting load of 20 g per bump). There is little change in all series connection resistance of all ~~the~~ junction portions even after 1000 cycles, and there is no substantial difference in ~~the~~ resistance change among the eight samples.

[00117] Fig. 15 is a photograph showing a cross section of a junction portion including a bump electrode and a pad electrode in a package structure of ~~the~~ an embodiment produced with a mounting load of 20 g per bump, and shows that ~~the~~ input/output terminal electrodes of a substrate thereof are not deformed under ~~the~~ this load, which makes packaging with a low stress possible. It is found from the above test results that a stable connection can be obtained with lower loads than in ~~the~~ a packaging method ~~of~~ using ~~the~~ conventional

anisotropic conductive film.

INDUSTRIAL APPLICABILITY

[00118] The circuit substrate of the invention, and the method of producing the same, can be utilized for producing and using substrates which are provided for ~~the~~ an electrical industry, particularly for ~~the~~ a semiconductor manufacturing industry. ~~The invention of the~~ A method of producing ~~the~~ a package structure of a semiconductor device can be widely used for production and use of semiconductor package structures in the electrical industry, particularly in the semiconductor manufacturing industry.

ABSTRACT OF THE DISCLOSURE

The invention is intended for providing a semiconductor package structure which prevents degradation in characteristics of a semiconductor device, and breakage of ~~the~~ interconnections, when the semiconductor device is packaged on a circuit substrate. In the package structure having the semiconductor device mounted on the circuit substrate, bump electrodes of the semiconductor device are placed on input/output terminal electrodes of the circuit substrate and are electrically and mechanically connected thereto by bonding with a conductive adhesive, and the semiconductor device is bonded and fixed to the circuit substrate by a resin film formed previously on a surface of a main body of the circuit substrate. The structure does no damage to a semiconductor functional part and to interconnections, and allows mounting with a lower load ~~in comparison with~~ as compared to structures using conventional anisotropic conductive films and the like~~, so that heat-press bonding mounting with a high productivity and a low cost can be applied~~.